Chapter 14
Harnessing 6G for Renewable Energy:
A Synergistic Path to Sustainability

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ABSTRACT

By offering ultra-reliable, low-latency communication, huge machine-type connection, and AI-driven intelligence, sixth-generation (6G) wireless technology is poised to revolutionise the renewable energy industry. SixG is becoming important for real-time energy management, predictive maintenance, and seamless integration of renewable sources as energy systems move towards distributed and smart grids. By means of case studies and literature research, this work examines the possibilities of 6G in optimising renewable energy production, transmission, and storage. SixG is projected to increase sustainability, grid resilience, and energy efficiency by using technologies like IoT, blockchain, and artificial intelligence. The paper emphasises important uses, difficulties, and future directions of research at the junction of 6G and renewable energy.

INTRODUCTION

The move to sustainable energy systems has become a global imperative as nations battle the twin challenges of growing energy demand and climate change.

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Solar, wind, hydro, and biomass are among the emerging, useful replacements for fossil fuels with better and more sustainable energy generating capability. However, the way these technologies are introduced into present energy systems introduces complexity related to unpredictability, real-time monitoring, grid stability, and energy storage (Zhang et al., 2020). Reacting to these challenges, the development of smart grids and intelligent energy systems has accelerated primarily dependent on advanced communication technologies. Sixth-generation (6G) wireless networks are on their approach, so renewable energy systems have a new horizon to become more intelligent, strong, and efficient.

Aimed for implementation in 2030, 6G represents a major revolution in wireless communications. It is expected to exceed 5G (Saad et al., 2020) with relation to speed (up to 1 Tbps), latency (sub-millisecond), reliability, and massive machine-type communications (MMTC). Six-G's unique properties—integrated artificial intelligence, distributed ledger technologies like blockchain, and the intersection of the physical and digital worlds via intelligent surfaces—can revolutionise energy production, administration, delivery, and consumption. By means of real-time monitoring of distributed renewable installations including wind farms and rooftop solar panels, 6G-enabled networks might, for instance, provide dynamic energy balancing and autonomous control (Feng et al., 2021).

Among the most revolutionary aspects of 6G is its capacity to support massive Internet of Things (IoT) deployments. In a networked energy ecosystem, data-generating nodes might include smart meters, energy storage systems, sensors for weather forecasting, electric automobiles (EVs). Edge computing driven by artificial intelligence allows these data points to be locally managed to enable fast decision-making for load forecasting, fault detection, and grid optimisation (Chen et al., 2021). A smart grid enabled by 6G may, for example, automatically reorganise itself in response to equipment failures or power fluctuations, hence improving energy efficiency and resilience free from human intervention.

Important for critical applications including the management of frequency fluctuations in power grids, emergency demand response during peak loads, and real-time coordination among distributed energy resources (DERs) is also 6G's support of ultra-reliable low-latency communication (URLLC) (Giordani et al., 2020). As the global energy sector gradually adopts decentralised and peer-to--peer (P2P) models (Kumar et al., 2022), blockchain-enabled microgrids might use 6G to facilitate secure, transparent, and practically instantaneous energy transactions among prosumers. These characteristics might significantly reduce transaction costs and boost local energy markets' trust and responsibility.

Moreover, profiting from 6G's potential in digital twinning and immersive visualisation are renewable energy sources.